NCEP's UNIFIED POST PROCESSOR (UPP)

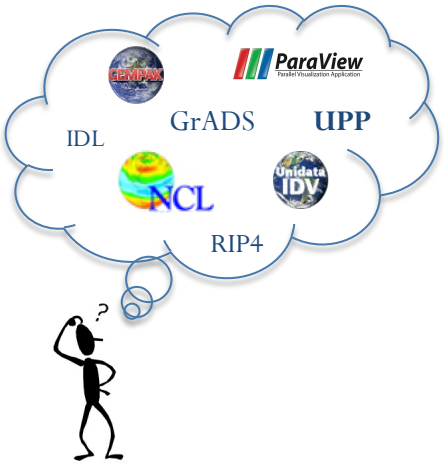
Presented by Kate Fossell

January 27, 2016

Outline

- Overview
- Components and Functions
- Sample fields generated
- Installing UPP
- Running *unipost*
  - Controlling output generation
- Running *copygb*
  - Specifying target grid
- Visualization

What is Post Processing and Why do I need it? Which one do I use?



- Turns model output into something meaningful:
  - Computes new fields not calculated in the model itself
    - Ex. RH is not output, only the variables T and water vapor needed to calculate RH are output
    - Ex. Height fields interpolated from model levels to 500mb and other pressure surfaces
  - Create maps and plots to visualize data

- Each has its strengths and weaknesses, often multiple are used to address specific needs
  - Need to ask yourself questions:
    - What do I need in the end?
    - Do I need nice 3d graphics to illustrate a phenomena?
    - Do I need flexibility to customize and manipulate fields?
    - Do I need a software that handles large files?

UPP Overview

- UPP is one of the many post processing packages available
- NCEP Developed & Supported Operationally
  - GFS, GEFS, NAM, SREF, RAPR, HRRR, HWRF, etc.
- NCAR Supports community code for WRF Post Processing

Why would you want to use UPP?

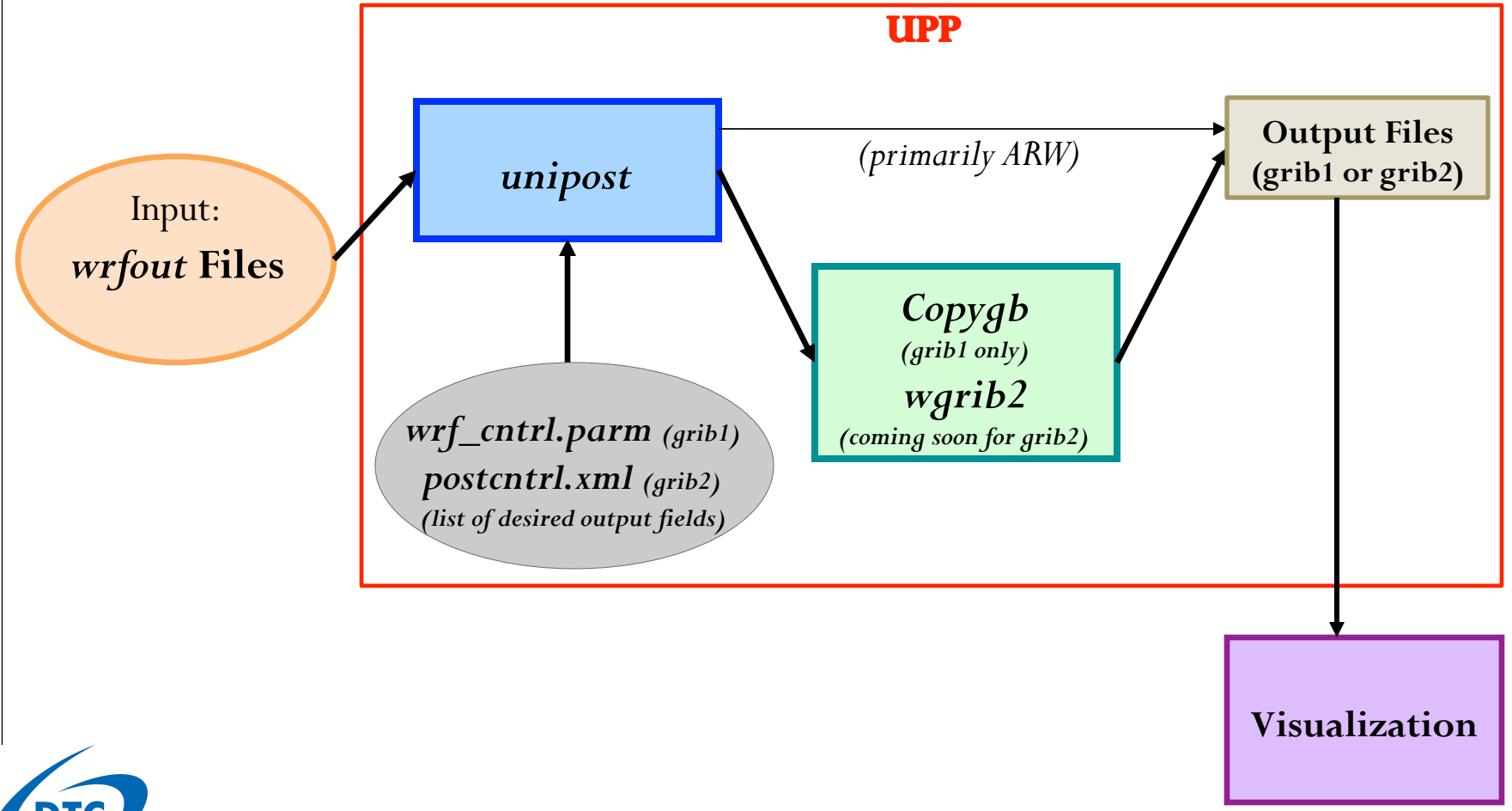
- Generates output in GRIB1 and GRIB2 format.
- Produces hundreds of products like those used operationally on same operational grids.
- Enables product generation on any output grid.

  E.g. MET: Regrid model data to match a observational grid for verification
- Processes model output from the NMM and the ARW dynamical cores (additionally NEMS-NMM-B).
- Produces requested diagnostics and fields, but does not plot or visualize data.
- MPI parallelized code

Components of the UPP

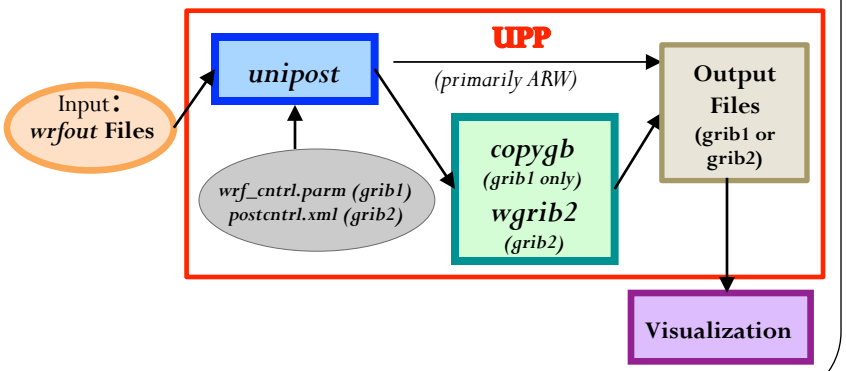
UPP has two components: 1) unipost 2) copygb (grib1 only)

(wgrib2 coming soon for grib2)



Unipost Functions & Features

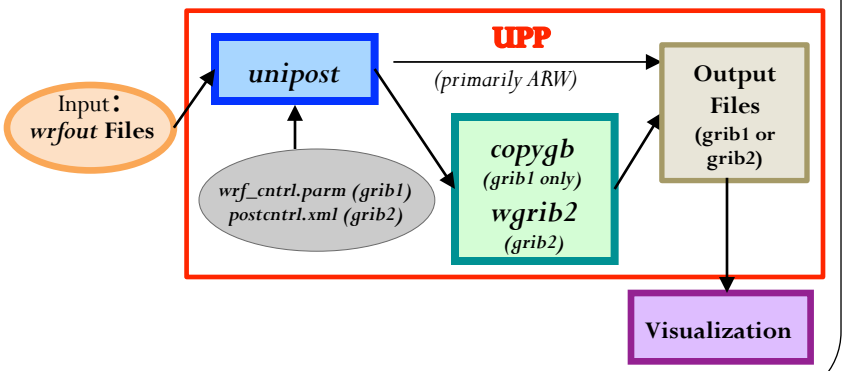
- Performs **vertical** interpolation from model levels/surfaces onto isobaric, height, and other levels/surfaces
- Computes **diagnostic** fields
- Destaggers wind onto mass points (ARW)
- An MPI-parallel code



Copygb
(grib1 format only)

Functions & Features

- Performs **horizontal** interpolation to a defined output grid
- Destaggers NMM grid
  - NOTE: many visualization packages cannot properly handle staggered grids
- Creates an output grid different than the model integration domain
  - e.g. Convert to operational grid: 221 (NAM, RAP, SREF)
  - e.g. Lambert ⟶ Lat-Lon
  - e.g. convert to observational grid



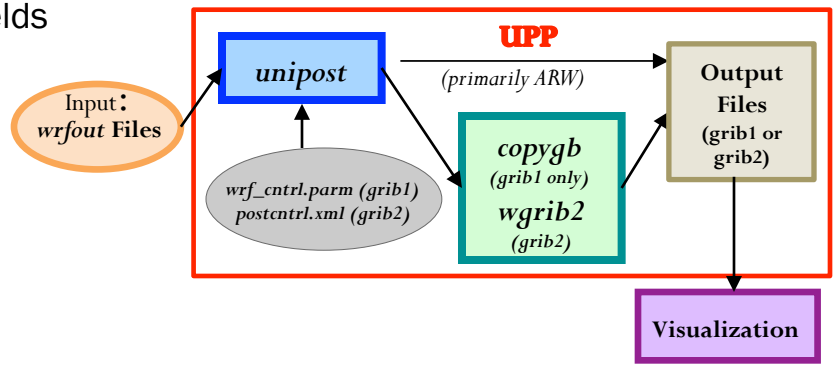
wgrib2
(grib2 format only)

wgrib2 will be used in coming release regridding grib2 output.

Ingesting WRF model output

Input:
wrfout Files

- The unipost ingests WRF model output in netCDF or binary format using the WRF I/O package.
  - Users are encouraged to use netCDF-formatted model output for simplicity.
  - Binary I/O is quicker for large file sizes.
  - One time per output file is best w/ sample UPP run scripts (frames_per_outfile=1 in WRF model namelist).
  - By default UPP tries to read a set list of fields in wrfout files.
    - Should contain necessary fields for diagnostics
    - Could impact UPP if you change registry or wrfout fields



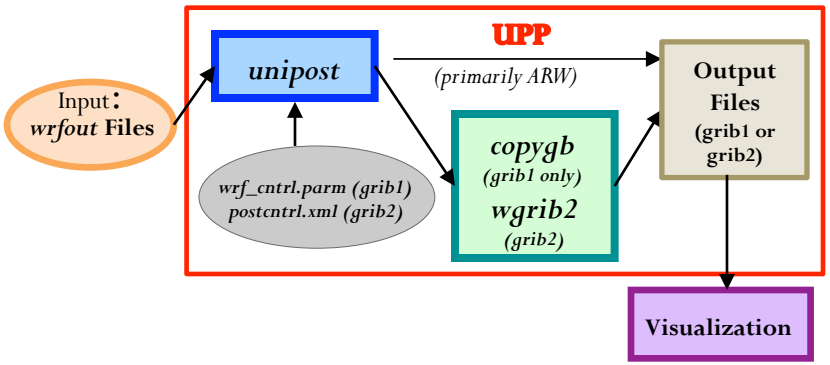
Fields generated by the UPP

Output Files (Grib1 or Grib2)

- **The UPP currently outputs hundreds of possible fields.**
  - Complete list in the Post Processing Utilities Chapter of the user guide
  - Fields are output in Grib1 format (some limited Grib2 format)

- **Sample fields generated by UPP:**

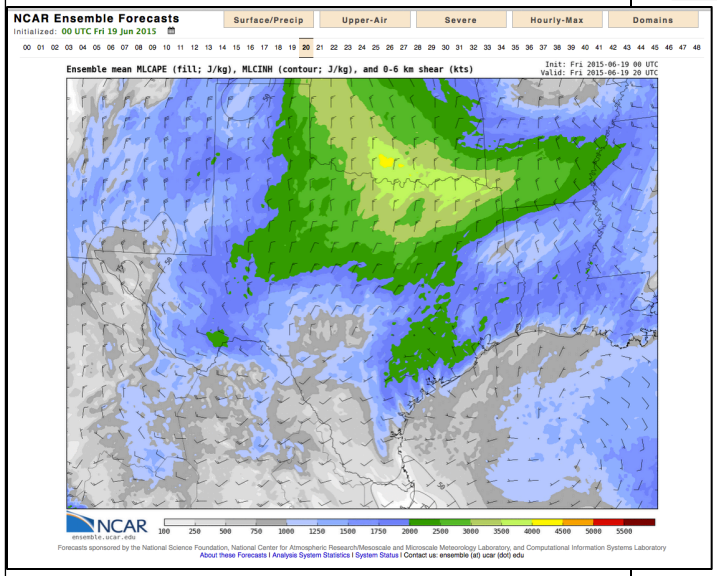
1) T, Z, humidity, wind, cloud water, cloud ice, rain, and snow on isobaric levels
2) SLP + shelter level T, humidity, and wind fields
3) Precipitation-related fields
4) PBL-related fields
5) Diagnostic products (i.e. RH, radar reflectivity, CAPE)
6) Radiative/Surface fluxes
7) Cloud related fields
8) Aviation products
9) Satellite look-alike products

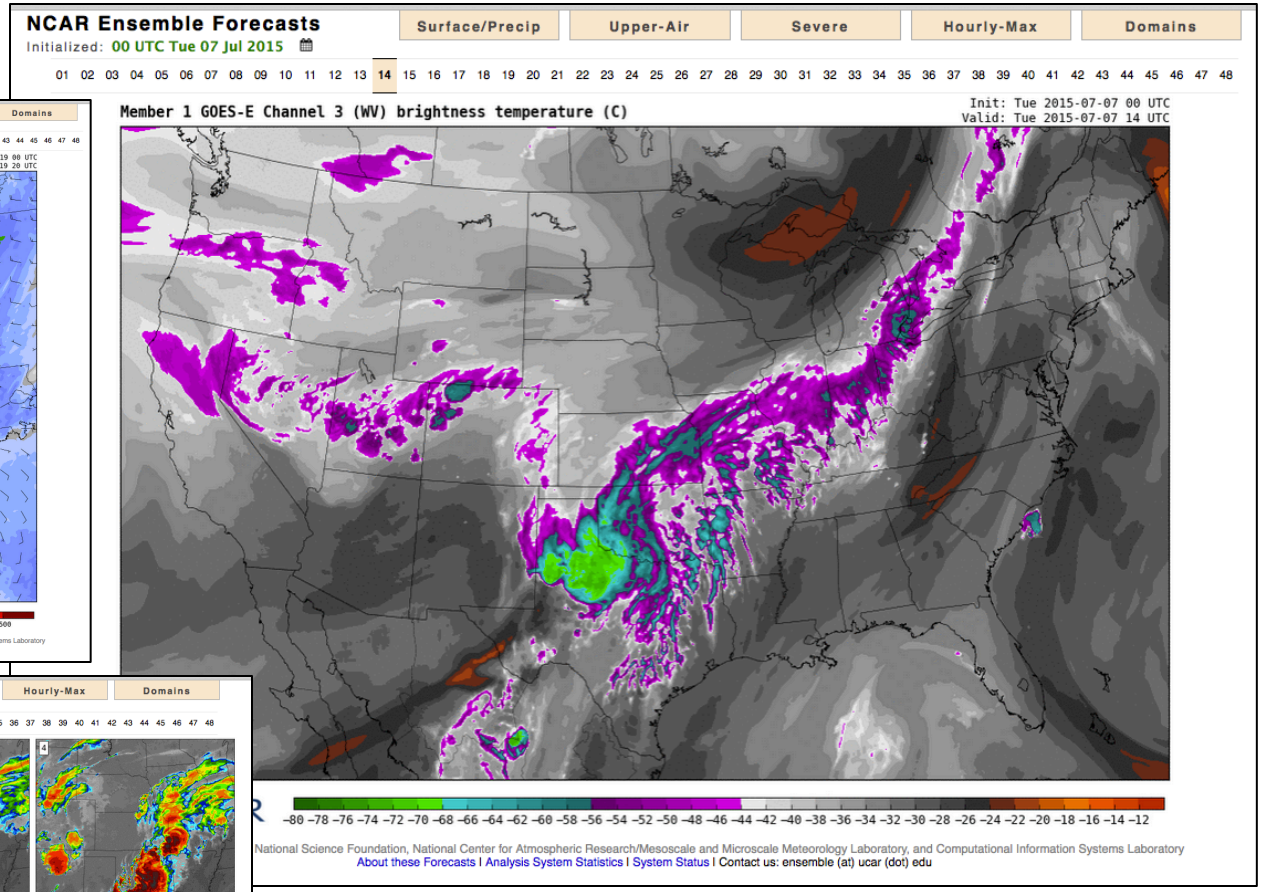


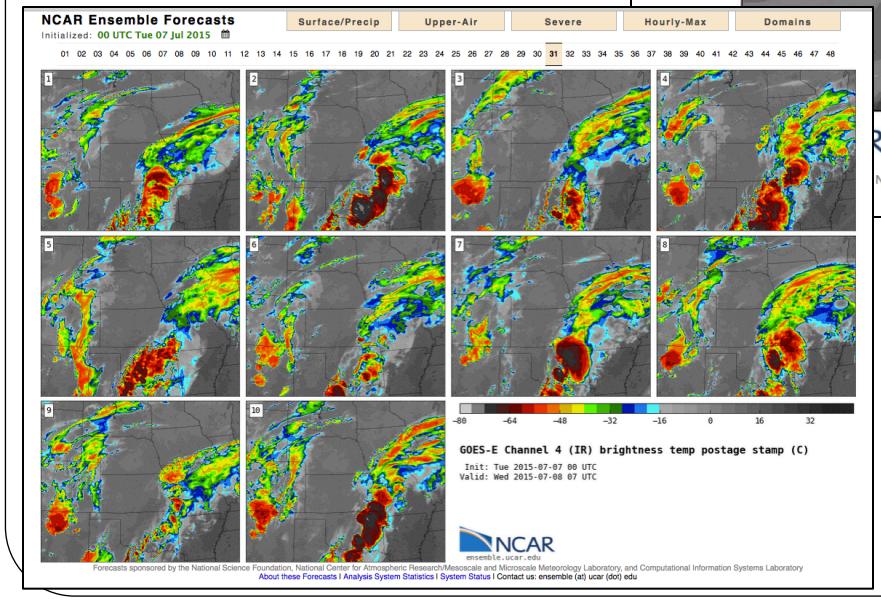
Outputting fields on different vertical coordinates

- *unipost* outputs on several vertical coordinates:
  - Native model levels
  - 47 isobaric levels: Default: 2, 5, 7, 10, 20, 30, 50, 70, then every 25 hPa from 75-1000 hPa.
  - 15 flight/wind energy levels: 30, 50, 80, 100, …, 2743, 3658, 4572, 6000 m (above ground or above MSL)
  - 6 PBL layers: each averaged over a 30 hPa deep layer
  - 2 AGL radar levels: 1000 & 4000
- Except for AGL radar and isobaric levels, vertical levels are listed from the ground surface up in *wrf_cntrl.parm (postcntrl.xml)*.

Example of UPP Products: NCAR Ensemble Forecasting System (www.ensemble.ucar.edu)







Upper Left: Mixed Layer CAPE
Upper Right: Synthetic Satellite Water Vapor
Lower Left: Synthetic Satellite Infared

*Note: diagnostic data generated with UPP; plots created with python utilities

UPP download and compile

UPP Dependencies & Required Libraries

- UPP build relies on the existence of a built WRF source directory. Uses WRF i/o routines.

- UPPV2.1+ depends on WRFV3.5 or later releases.

- Libraries required:
  - netCDF
  - JasPer
  - PNG
  - Zlib
  - WRF i/o libs

Downloading the UPP source code

- The UPP source code can be obtained from:
  http://www.dtcenter.org/upp/users/downloads/index.php
  - The latest version available is: UPPV3.0.tar.gz
- Unpack the downloaded file:
  tar –zxvf UPPV3.0.*tar.gz*
- *cd* to newly created UPPV3.0/ directory
  - Important Directories:
    - **scripts/**: sample scripts for running UPP and generating graphics
    - **parm/**: contains the files used to request output fields when running the unipost (i.e. wrf_cntrl.parm, postcntrl.xml)
    - **clean, configure, compile**: scripts used in the build process

wrf_cntrl.parm (grib1)
postcntrl.xml (grib2)

Compile source codes

- The build mechanism follows the WRF model build paradigm:

  ./configure : respond to screen prompts about target computing platform

- *./compile >& compile_upp.log*

Compile source codes (cont.)

- If compilation is successful, these three executables will be present in bin/ :

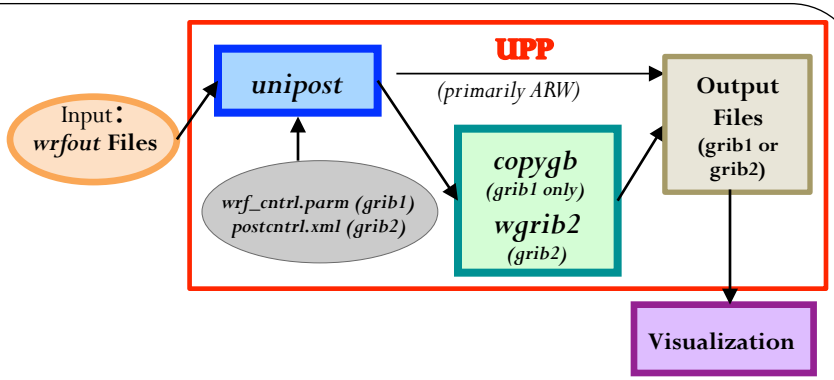
  copygb.exe
  ndate.exe
  unipost.exe

- Currently have build options established for IBM (AIX) and Linux (PGI/Intel/Gnu compilers)

- The arch/configure.defaults file has compilation options for various platforms, and is where new computers or compilers might be added.

Running unipost and copygb

Running UPP



* Use sample scripts as a template or guide to run UPP *

Run Script: ./run_unipost >& script_output.log &

- run_unipost is a korn shell script that runs UPP end to end: unipost + copygb (if needed)
- User edits paths, date, time, command syntax (serial vs. parallel) in script.
- Links all required files, loops over times/files and processes fields requested fields from wrf_cntrl.parm, runs copygb if necessary.
- Unipost.exe output/error messages is redirected to log files, e.g. unipost_d01.00.out. Look in these files for information about errors.

Unipost

Running unipost.exe

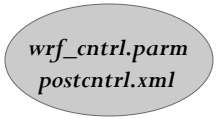
** Requires 3 input files to run **

1) *itag*: 4-5 line text file that details WRF model output to process. Also referred to as the namelist.

```
wrfout_d01_2010-06-27_00:00:00      <-- WRF history filename
netcdf                              <-- WRF output format (netcdf/binary)
grib2                               <-- extra line only if writing GRIB2

2010-06-27_00:00:00                 <-- validation time
NCAR                                <-- model name: "NMM" -or- "NCAR" (ARW)
```

2) *wrf_cntrl.parm (grib1)* : control file specifying fields/levels to output in GRIB1 (*text file*)
postcntrl.xml (grib2) : control file specifying fields/levels to output in GRIB2 (*xml file*)



3) *eta_micro_lookup.dat*: binary look-up table for Ferrier MP (linked from WRF)

*** In the sample scripts/run_unipost* scripts, these files are automatically generated (itag) or linked (wrf_cntrl.parm & eta_micro_lookup.dat).

unipost control file for grib1 :

wrf_cntrl.parm (Grib1)

- User controlled and modified text file that lists fields and level(s) of fields to output; each product described by 2 lines (Examples next slides)

- The included parm/*wrf_cntrl.parm* file has entries for most output fields. ** Use this as template! ** (Text file fixed width format)

- The users' guide "Fields produced by *unipost*" (Table 3) more fully explains the character string abbreviations used in the wrf_cntrl.parm file.

unipost control file: *wrf_cntrl.parm*

wrf_cntrl.parm (Grib1)

- Each field described by 2 lines: product description and levels

```
(PRESS ON MDL SFCS  ) SCAL=(6.0)
L=(11000 00000 00000 00000 00000 00000 00000…
(HEIGHT ON MDL SFCS ) SCAL=(6.0)
L=(11000 00000 00000 00000 00000 00000 00000…
```

GRIB packing precision**

Levels to output: Each column represents a single model/isobaric level:
"1" (or "2" - special case) = output, "0" = no output

Product description – unipost code keys on these character strings.

** larger values → more precision, but larger GRIB files.

Examples

wrf_cntrl.parm (Grib1)

- Output T every 50 hPa from 50 hPa to 1000 hPa:

```
(TEMP ON PRESS SFCS  ) SCAL=( 4.0)
L=(00000  01001  01...)
                2   5   7  10  20     30 50 70 75 100
```

*** Isobaric levels increase from left to right:
2, 5, 7, 10, 20, 30, 50, 70, then every 25 hPa from 75-1000 hPa.
(Default/standard – can manually change code for different pressure levels)

Isobaric levels every 50 hPa:

```
L=(00000 01001 01010 10101 01010 10101 01010 10101 01010 10000 00000 00000 00000 00000)
```

Isobaric levels every 25 hPa:

```
L=(00000 01011 11111 11111 11111 11111 11111 11111 11111 10000 00000 00000 00000 00000)
```

Examples

wrf_cntrl.parm (Grib1)

- Output instantaneous surface sensible heat flux:

```
(INST SFC SENHEAT FX ) SCAL=( 4.0)
L=(10000 00000 00000 00000 00000 00000 00000 00000 00000 00000…)
```

- Output the U-wind component at the 5 lowest model levels:

```
(U WIND ON MDL SFCS  ) SCAL=( 4.0)
L=(11111 00000 00000 00000 00000 00000 00000 00000 00000 00000…)
```

- Output U-wind component at 30, 50, and 80 m AGL:

```
(U WIND AT FD HEIGHT) SCAL=( 4.0)
L=(22200 00000 00000 00000 00000 00000 00000 00000 00000 00000…)
```

For the flight/wind energy level fields:
- "2" requests AGL.
- "1" requests above mean sea level.

unipost control file for grib2 :

postcntrl.xml (Grib2)

- User controlled xml file that lists desired fields to be output by UPP.
- The included parm/*postcntrl.xml* file has examples of the template to follow. More fields to be added and as they are tested.
- The included parm/*post_avblcntrl.xml* file has a listing of all available field names, shortnames, parameter info.
- Grib2 shortnames to be added in the Users' Guide in the near future, can also be mapped using RQSTFLD.f

unipost control file: *post_avblflds.xml*

postcntrl.xml (Grib2)

- Lists all available fields and details for grib2 tables/output
- Does not need to be modified unless adding new variables or modifying from default.

```
<param>
    <post_avblfldidx>2</post_avblfldidx>
    <shortname>TMP_ON_HYBRID_LVL</shortname>
    <pname> TMP</pname>
    <fixed_sfc1_type>hybrid_lvl</fixed_sfc1_type>
    <scale>4.0</scale>
 </param>

 <param>
    <post_avblfldidx>70</post_avblfldidx>
    <shortname>DPT_ON_SPEC_PRES_ABOVE_GRND</shortname>
    <pname>DPT</pname>
    <fixed_sfc1_type>spec_pres_above_grnd</fixed_sfc1_type>
    <scale>3.0</scale>
 </param>
```

- Character name describing the product/field
- Vertical coordinate type
- Grib precision packing
- Field type abbreviation used by internal libraries

unipost control file: *postcntrl.xml*

postcntrl.xml (Grib2)

- User modified xml file to list all desired fields to be output by UPP
- Use provided file as a guide

```
<param>
    <shortname>TMP_ON_SPEC_HGT_LVL_ABOVE_GRND_2m</shortname>
    <scale>-4.0</scale>
</param>

<param>
     <shortname> UGRD_ON_ISOBARIC_SFC</shortname>
     <scale> -4.0 </scale>
     <level> 50000. 70000. 85000. 92500. 100000. </level>
</param>
```

- Character name describing the product/field
- Vertical coordinate levels desired
- Grib precision packing

Copygb
(grib1 format only)

When to run it

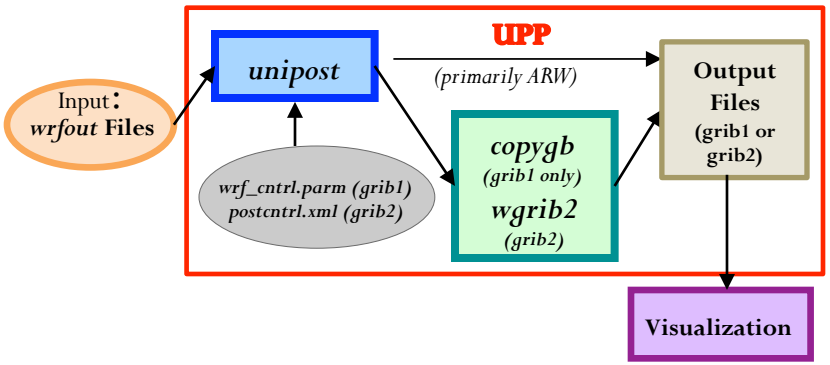
1) If using NMM – need to run copygb to de-stagger the grid.

- Sample scripts contain a flag for NMM that will run it automatically
- Default in scripts uses grid navigation file generated by UPP.
- Must edit the script to use pre-defined grid or custom grid.

2) If you want your output on a grid different from the model

i.e. changing from lambert projection to lat-lon projection

*** Testing underway for a utility to de-stagger and regrid grib2 output. Will be released when ready. ***

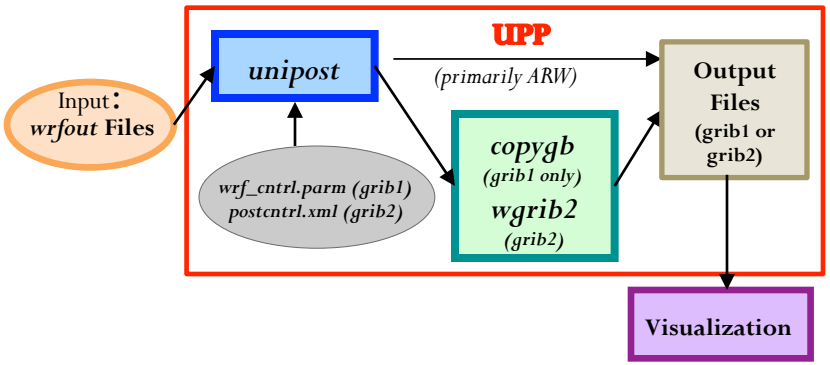


Copygb (*grib1 format only*) target grid definition

- The generic command to run copygb and horizontally interpolate onto a new grid is:

copygb.exe –xg"${grid}" in.grb out.grb

- Three options on how to specify the target $grid:
  1. Pre-defined NCEP standard grid number
  2. Grid navigation file created by *unipost* (NMM only)
  3. User-defined grid definition



Run *copygb* – Option 1

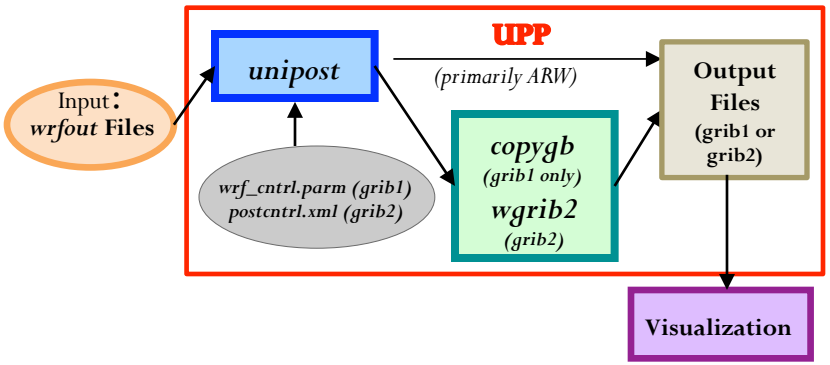
Copygb
(grib1 format only)

- Interpolate to a pre-defined NCEP standard grid (restrictive but simple)
  - For example, to interpolate onto NCEP grid 212:

    copygb.exe –xg212 in.grb out.grb

Descriptions of NCEP grids are available online:

http://www.nco.ncep.noaa.gov/pmb/docs/on388/tableb.html



Run *copygb* – Option 2

Copygb
(grib1 format only)

- Read in grid navigation file created by *unipost* (NMM only, simple, restrictive)

  - Running *unipost* on WRF-NMM output produces two ASCII files containing grid navigation information which is similar in domain and grid spacing to the model integration domain.
    - *copygb_gridnav.txt* for a Lambert Conformal grid
    - *copygb_hwrf.txt* for a regular Lat-Lon grid

  For example:

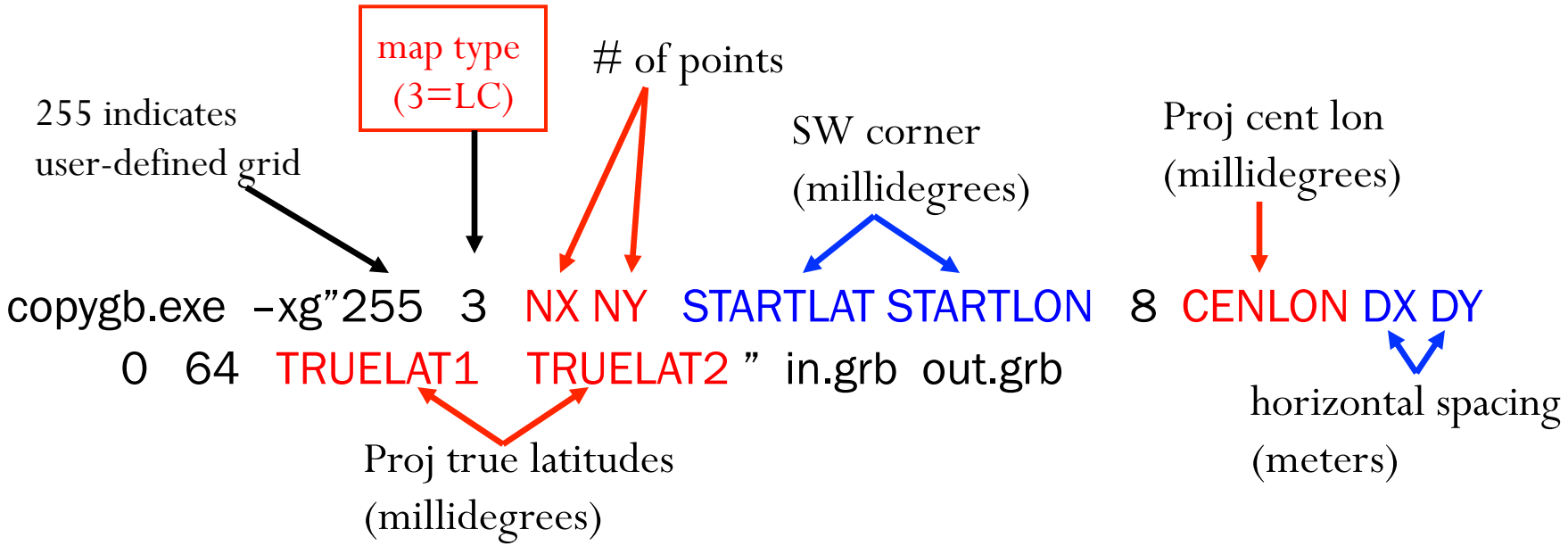
  read nav < 'copygb_gridnav.txt'

  copygb.exe –xg"${nav}" in.grb out.grb

Run *copygb* – Option 3a

Copygb
(grib1 format only)

- Create a user-defined ***Lambert Conformal*** grid by specifying a full set of grid parameters (complicated but flexible).



```
copygb –xg"255 3 185 129 12190 -133459 8 -95000 40635 40635
       0   64  25000  25000" in.grb  out.grb
```

Run *copygb* – Option 3b

Copygb
(grib1 format only)

- Create a user-defined ***Polar Stereographic*** *grid* by specifying a full set of grid parameters (complicated but flexible).

map type (5=STR)

copygb.exe –xg"255 5 NX NY STARTLAT STARTLON 8 CENLON DX DY
0 64" in.grb out.grb

Center flag (0=NH ; 1=SH)

---

copygb –xg"255 5 580 548 10000 -128000 8 -105000 15000 15000
0 64" in.grb out.grb

Run *copygb* – Option 3c

Copygb
(grib1 format only)

- Create a user-defined ***Latitude-Longitude*** *grid* by specifying a full set of grid parameters (complicated but flexible).

map type (0=LTLN)

copygb.exe –xg"255 0 NX NY STARTLAT STARTLON 136 ENDLAT ENDLON
DLAT DLON 64" in.grb out.grb

grid spacing (millidegrees)

NE lat (millidegrees)

NE lon (millidegrees)

---

copygb –xg"255 0 401 401 10000 -130000 136 50000 -90000
100 100 64" in.grb out.grb

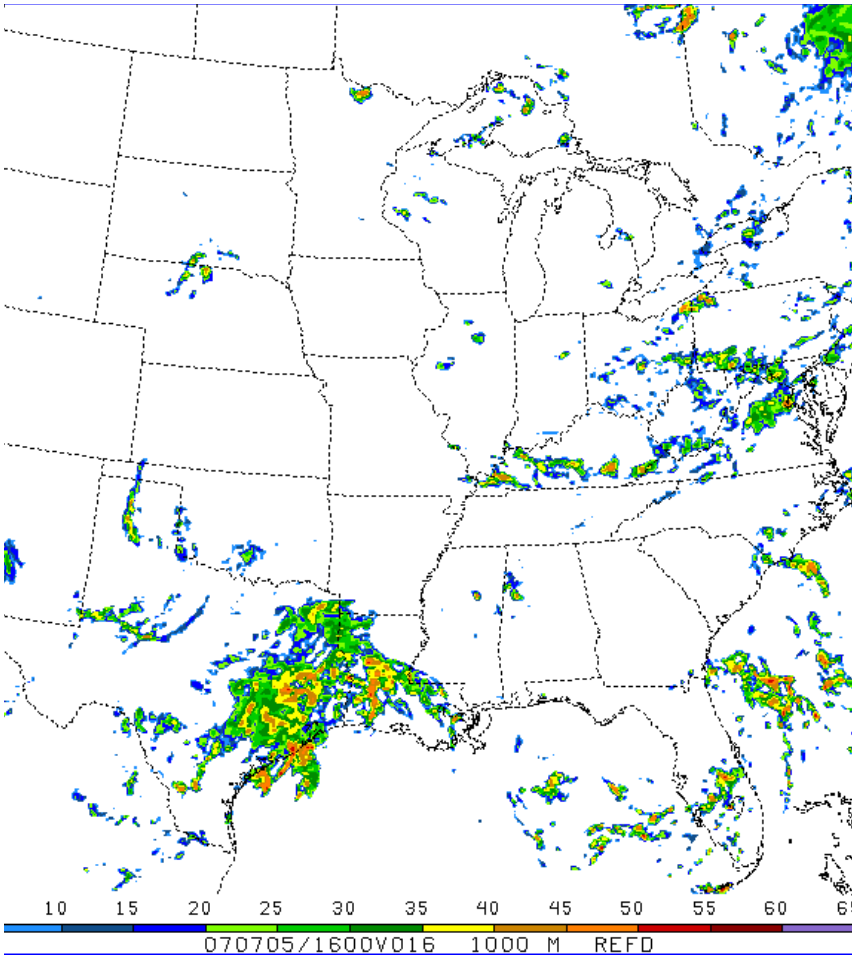
Visualization: GEMPAK

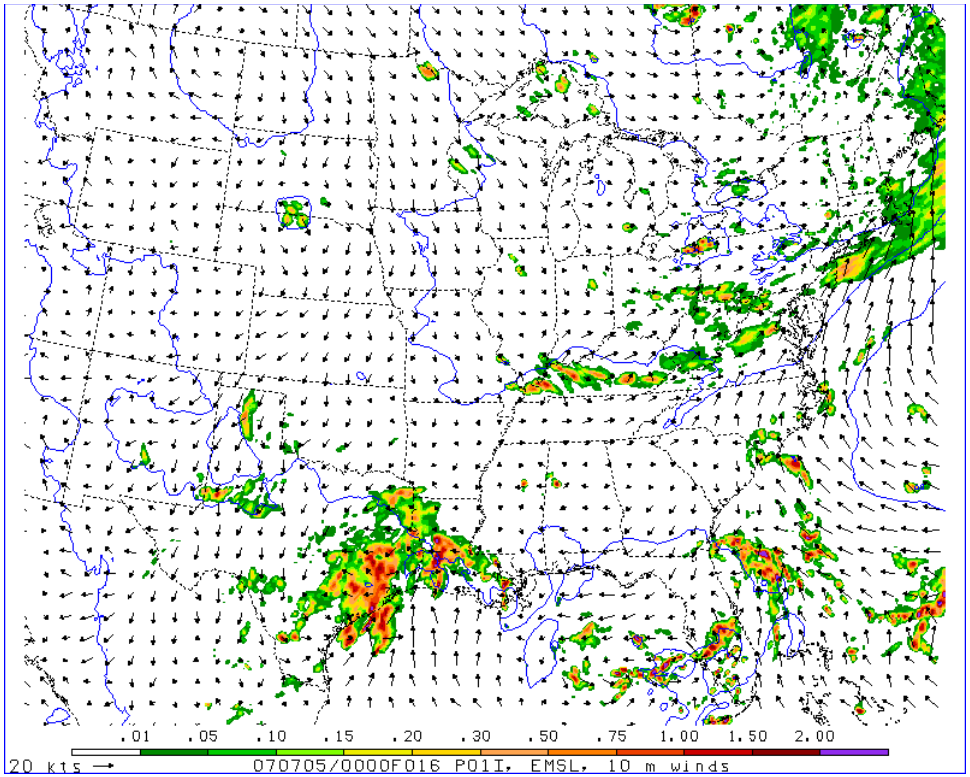
- The GEMPAK utility "nagrib" reads GRIB files from any non-staggered grid and generates GEMPAK-binary files that are readable by GEMPAK plotting programs
- GEMPAK can plot horizontal maps, vertical cross-sections, meteograms, and sounding profiles.
- Package download and user guide are available online:

  http://www.unidata.ucar.edu/software/gempak/index.html

- A sample script named *run_unipostandgempak* is included in scripts/ that can be used to run *unipost*, *copygb*, and then plot various fields using GEMPAK.
- Further details on this script and using GEMPAK are available in the user's guide.

Forecast plotted with GEMPAK : Precipitation and derived Radar reflectivity





Visualization: GrADS

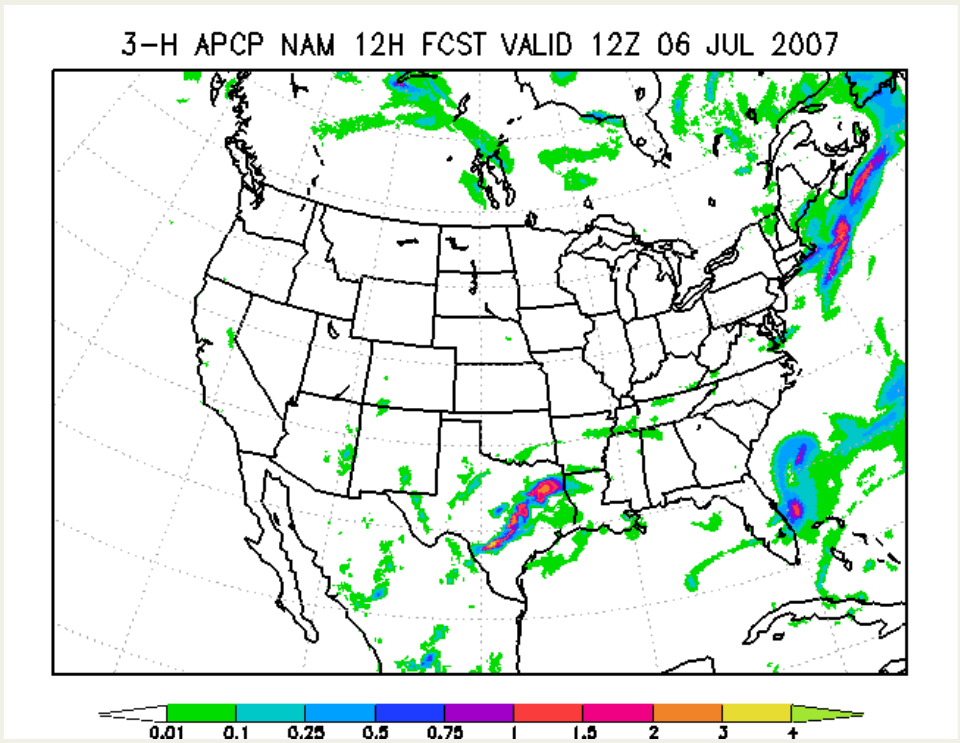
- GrADS also has utilities to read GRIB files on any non-staggered grids and generate GrADS "control" files. The utilities grib2ctl and gribmap are available via: http://www.cpc.ncep.noaa.gov/products/wesley/grib2ctl.html

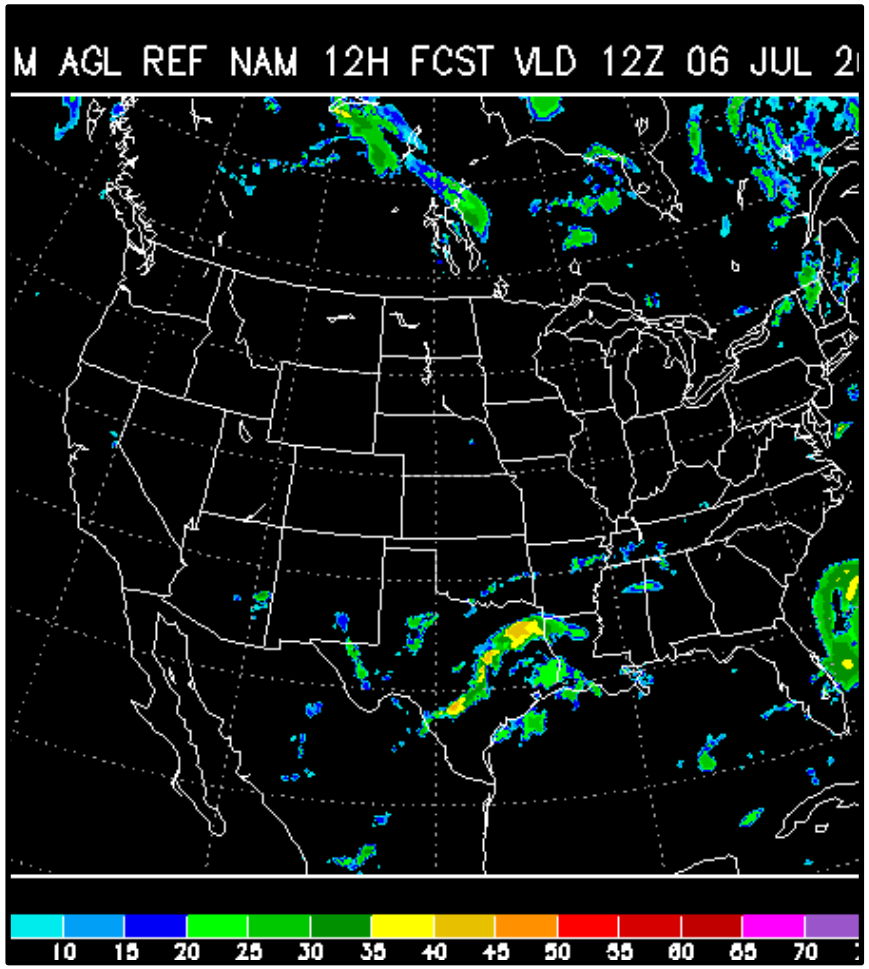
- Package download and user guide for GrADS are available online: http://grads.iges.org/grads/gadoc/

- A sample script named *run_unipostandgrads* is included in scripts/ that can be used to run *unipost*, *copygb*, and then plot various fields using GrADS.

Forecast plotted with GrADS:

Precipitation and derived Radar reflectivity





Future plans

- Improvement of generation of GRIB2 output.
  - Grib2 xml templates and product generation
  - Speed up of xml read
- Utility for regridding / destaggering grib2 output (similar to copygb for grib1)
  - wgrib2 to be released in future versions
- Continue adding new products to the released UPP code as they are developed, and expand code portability.

Helpful Links:

New UPP Website:
http://www.dtcenter.org/upp/users/index.php

UPP Users' Guide available at:
http://www.dtcenter.org/upp/users/docs/user_guide/V3/upp_users_guide.pdf

UPP FAQ's Page:
http://www.dtcenter.org/upp/users/overview/upp_faqs.php

For UPP Questions Contact: upp-help@ucar.edu

Questions???